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COMMENTS ON CURRENT TRENDS IN RESEARCH ON THE STRUCTURAL STABILIZATION OF AUSTENITIC STEELS CONTAINING MANGANESE

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16. Abstract

Review of ways by which austenitic steels may be stabilized, which include the addition of a certain amount of nickel, chilling by stages, and elimination of phosphorus, which causes embrittlement. The intent of the metallurgist is to develop a manganese steel of fine austenitic structure which, after overtempering, is sufficiently stable to maintain in service the toughness which it owes to this structure, but at the same time is sensitive, on its surface, to martensitic transformation by hammer hardening.

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COMMENTS ON CURRENT TRENDS IN RESEARCH ON THE STRUCTURAL STABILIZATION OF AUSTENITIC STEELS CONTAINING MANGANESE

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The broad area of research on the structure and constitution of austenitic steels containing manganese is increasingly extending in all directions, so that we are justified in asking whether we have not lost sight of the thread leading to the ideal composition of that valuable steel, which has been studied since Hadfield.

What, exactly, is the problem? It is to prepare a steel containing manganese having fine and austenitic structure after hyper-tempering, stable enough to retain during use the toughness which it owes to that structure, but sufficiently susceptible at the surface to martensic transformation by hammer-hardening — through pressure, shock or friction. It must acquire extreme hardness in this process. This association of superficial martensite with tough austenite in the core, in which the very fine needles of martensite are solidly embedded, results in the well-warranted reputation of resistance to wear which is a characteristic property of the Hadfield steels. This material has advantages over white cast irons, hard irons and steels containing chromium-molybdenum, and other siderurgic products resistant to abrasion which themselves possess a homogeneous and stable structure. These

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advantages essentially reside in the toughness of the austenitic mass and the capability for structural transformation localized at the site of attack by tools, as well as in the automatic formation of a new, hardened martensic layer after wear of the superficial layer, a process which continues to repeat itself indefinitely.

To summarize, in order for steel to respond to expectations in use, it is necessary for this structural transformation to take place. It follows that research on final stabilization of the austenite — for example, by the addition of gammagenic substances such as nickel — cannot lead to the desired result, particularly because the proposed elements of addition simultaneously lead to a reduction in the hardness of the austenite itself and the products of its transformation, if any.

Nevertheless, it is in this direction that the vast majority of investigators channel their efforts. It should be noted, however — to the credit of steels containing a particular percentage of nickel — that these steels are more weldable than the traditional steels. Welding involves heat, which itself is a second factor favoring the transformation of austenite. Obviously it is just as necessary to control this effect, particularly because the transformation austenite → martensite is then no longer limited to the surface, where it is beneficial, but extends to the entire mass. In proportion to the increase in the martensite content, the material becomes more and more fragile. Steel containing manganese then has no advantage over its competitors, in which fragility is the most dreaded and the most characteristic fault.

In this sense also, one must try to stabilize austenite by making it as independent as possible of heating. We have seen up to now that the addition of a small amount of nickel led to favorable results. It must now be determined whether these additives are indispensible or if they can be replaced by other things.

Another area of research which has been increasingly explored is that of the structures obtained during cooling in stages. From a purely theoretical point of view, this area of research is undoubtedly of considerable interest. It cannot, however, lead to stable structures of steel which are at the same time tough and very hard, whatever the constitution of the steel might be. / 772

In the last few years, work relating to the so-called "Hadfield" steels has reappeared, but in these the manganese content is diminished as much as possible to obtain an austenitic steel. The published results with these steels, of relatively high phosphorus content, are surprising with respect to their resilience as much as their resistance to wear. What we find difficult to understand is that, given these results, the steels of 7% to 9% manganese have not cornered the market for "industrial" steels. According to the authors of these studies, such steels should be superior to all commercial steels. Nevertheless, almost all the steel works specializing in the manufacture of steel containing manganese continue to deliver the more costly steels of traditional composition.

It is altogether surprising that only a few investigators should apply themselves to investigating the effects of phosphorus on the fragility of steels containing manganese, and on their susceptibility to structural transformation. For, in fact, the problem of fragility appears to be simplified with all of these steels. If not poor in sulfur, they contain only sulfur associated with manganese in the form of manganese sulfide because of their manganese content, and this sulfur is harmless.

Thus, among the traditional fragilizing elements there remains only phosphorus. Why has it received so little attention?

Of course, here and there in the literature we find numerous articles or research reports mentioning, in a list of steels investigated, a variety particularly poor in phosphorus, but no one continues at this point. To our knowledge, there are hardly any systematic studies on the effects of low concentrations of phosphorus.

In conjunction with our industrial and laboratory studies relating to the production of these steels and the relationships between composition and structural stability, we have undertaken an extensive study of these reciprocal effects by entirely different and original means.

The federal Swiss railroads, in fact, have engaged the Institute of Metals and Machinery of the Federal Polytechnic School of Lausanne (until 1968, called L.E.M.E.P.U.L., Laboratory for the Analysis of Materials, Polytechnic School of the University of Lausanne) to study and develop procedures for welding repairs of railway crossings, rails, and segments of railway tracks made of austenitic steel containing manganese.*

This is the research which we have conducted as part of a series of studies on procedures for welding repairs of steels containing manganese. We worked to develop the most adequate technique for repairing without incurring the risk of transforming and fragilizing the austenitic core. It was necessary to study, in addition, methods for removing test pieces for analysis and, above all, the ideal composition of metals for applications.

* We take this opportunity to thank the Federal Swiss Railroads, and particularly Dr. Simon, of the general management, who kindly authorized the publication of portions of this research.

It is clear that the manufacturers of electrodes took particular care in the production of this metal for application, and it is thus that we were able to achieve extensive repairs in steels with 12-14% manganese containing only traces of phosphorus (<0.01%). These are the repaired metals of high purity which allowed us to pursue our studies.

It seems as though phosphorus, in this case, exerts its classic fragilizing influence insofar as the element is dissolved in iron. Why is it that no one has previously considered this effect and carried out research in this area, instead of being sidetracked into the theoretical study of structures obtained with cooling in well-defined conditions or of steels enriched with nickel or molybdenum? We find this hard to understand.

Yet there is another process, even more interesting, to consider. This is the role which may be played by eutectic phosphate, as distinguished from dissolved phosphate. The formation of eutectic phosphate is unavoidable; it is precipitated at the seams by the separation of precipitated particles which are definitely the beginning of the formation of martensitic seeds.

The details and the development of procedures for extraordinarily rapid structural modification, to harden and fragilize the superficial layer simultaneously, have not yet been studied in a fundamental manner. However, the later work of our collaborator, M. Louis Casas, has already resolved the problems involved with methods of repair and taking of samples, and with the characteristic effects of phosphorus on the stability of austenite. In addition, we intend to proceed with the publication of our work and hope that these comments will prompt other institutions to begin new work along these lines on this valuable steel with 12% - 14% manganese.

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